moved slowly eastward, although there were fresh southwest winds aloft to the west and southwest, and on October 29 and December 21, 1920, and January 2, 1922, when there was a deep stationary cyclone over Newfoundland and the winds aloft over the northeastern States were strong northwest. All of these 5 anticyclones moved slowly.

It is quite interesting to note that when Alberta or Manitoba anticyclones reach the eastern States with major axis north-south and fresh to strong southwest winds set in aloft, say from Oklahoma northward and north-eastward, but remain only moderate southwest aloft over the Gulf States, the direction of the major axis is invariably shifted from north-south to northeast-southwest, the southern end remaining almost fixed in position, i. e., pressure decreases rapidly east of the upper Mississippi Valley and a cyclone moves eastward over this region, while the barometer falls very slowly over the southeastern States and generally rises at Hamilton, Bermuda. If, at the same time, there is a deep stationary cyclone in the vicinity of Newfoundland, the northern end of the anticyclone will disappear entirely (see map of Feb. 15, 1921). This condition is peculiar to anticyclones that move southeastward from Alberta or Manitoba. One anticyclone, that of December 30, 1921, was originally tabulated as of Pacific origin, but being the only one, a further investigation was made and it was found that, while it originally appeared on the Pacific coast, it was reinforced from the Canadian Northwest on December 28, thereafter partaking of the nature of an Alberta anticyclone. It has been found from previous observation and from this study that whenever a Pacific anticyclone is reinforced by an anallobar moving down from the Canadian Northwest it becomes an Alberta anticyclone in fact; furthermore, if either a Pacific or an Alberta anticyclone is reinforced from the Hudson Bay region its future course is the same as if it came originally from that region.

It will be observed that each of the five stationary anticyclones was very deep and controlled the upper winds far to the westward. A striking example was the anticyclone of the last week in October, 1921, the note made in connection with it being as follows:

October 25.—Anticyclone 30.3 [inches] over Ontario. Moderate to fresh east and southeast winds aloft from Lansing and Royal Center westward. Gentle southwest winds in west Gulf States. Anticyclone moved slowly southeastward over northeastern States, then remained stationary with lessening intensity until end of month. Stationary cyclone over Newfoundland. Winds aloft remained southeast to northeast at Royal Center during entire period and two Colorado disturbances of marked intensity were retarded, partially filled up, and diverted from normal path.

As a result of this study and of the day-to-day examination of the aerological charts the writer is convinced that, given sufficient upper-air observations, the forecaster can predict with a great deal of confidence the future course and the rate of movement of practically every anticyclone.

HIGH-LEVEL ISOBARS AS USED IN EVERY-DAY WEATHER SERVICE.

By RIKICHI SEKIGUCHI.

[Cambridge, England, Apr. 5, 1922.]

NOTE.—Through the courtesy of Prof. V. Bjerknes, Doctor Sekiguchi has kindly prepared for the REVIEW the paper which he delivered before the International Commission for the investigation of the Upper Air held at Bergen, Norway, July 25-30, 1921.[1] Doctor Sekiguchi has had extensive experience in the application of maps of free-air pressure[2] to forecasting in Japan.—EDITOR.

The present communication is a short summary of the author's two years' experience in his weather service, in cooperation with Dr. S. Fujiwhara and Dr. Y. Horiguchi, at Osaka and Kobe. Several trials in the use of high-level isobars were made with the hope of finding some help for predicting the change of weather type with greater certainty than the ordinary synoptic charts alone can afford. At first (the spring of 1918), the 1,000-meter level was chosen for daily use and proved itself very useful in predicting movements of cyclonic centers. Later on, charts for the 3,000-meter level were added to the scheme and even 6,000-meter isobars were drawn occasionally. But after some experience having found the 3,000-meter chart most useful, the author confined his attention mainly to that level.

In drawing isobars, the values of pressure on the respective levels must be entirely based on the observed surface values of certain meteorological elements and certain assumptions concerning the lapse rate of temperature. The method of drawing isobars had nothing different from that which is being generally used in making ordinary synoptic charts, except that on the high levels there was no information concerning the wind to be taken into account in checking the trend of isobars, as is usually done on the sea-level chart.

At first the complexity of the trend of the isobars as influenced by local abnormality of surface air temperatures was a perplexing feature. But as the author became somewhat experienced in this method he could get rid of this complexity to some extent by making due allowances for the abnormalities that might be estimated to some degree from the topographic conditions, temperature changes, the state of the sky, etc. After some study it has been found that the general trend of the upper isobars in general was not so much affected by the actual lapse rate being unknown as it was at first feared. The remaining abnormalities seemed to have caused no great disturbances in considering the general trend of isobars in the majority of cases. Moreover, for the sake of safety, the high-level charts were based on the data from coast stations only, as far as it was possible, in view of minimizing the effect of surface inversion. Some of the results of investigations are summarized as follows:

(1) The movements of cyclonic centers in the Far East showed in most cases fair accordance with the general trend of the 3,000-meter isobars,[3] showing the less dependence upon the trend of sea-level isobars.

(2) The region where the general trend of both systems of isobars (free-air and sea-level) ran nearly parallel to each other was never passed by a cyclone which happened to be in the neighborhood at that moment. This fact seems to be in fair accord with the current idea that cyclones tend to be drifted by the prevailing upper-air current, if the upper isobars are assumed as identical with the stream lines on that level.

(3) When both systems of isobars ran nearly parallel on three sides—that is, on the front, right, and left—of the path of the cyclone, that cyclone was observed to be generally stationary. Similar phenomena were almost invariably observed when the wedges of high pressure

[1] Cf. *Proceedings*, p. 23.
[2] Cf. Fujiwhara, S.: Pressure maps at 3 kilometers in Japan. MO. WEATHER REV., Oct., 1921.

[3] Mr. C. L. Mitchell points out numerous similar cases where anticyclonic movement in the United States was in agreement with the direction and speed of upper currents. This REVIEW, pp. 241-242. EDITOR.

areas pressed upon the front of the cyclone from both sides of the track. The space between the wedges was called "the gate of the cyclone" because typhoons showed a tendency to move toward the "gate" but could not make any remarkable advance as long as the "gate" remained shut; it rushed through as soon as the "gate" was opened.

(4) Most cyclones showed decided tendencies to move toward the region where unmistakable cross-intersections of upper and lower isobars could be perceived. These "crosses" also indicated the weather declining there most rapidly, while in the region of "parallel" the weather usually continued to be fair.

(5) Two different classes of "crosses" have been distinguished: One, indicative of a lower drift, turned 90° counterclockwise from the direction of the upper drift, and the other indicative of the opposite turning. The cyclone-attracting tendency of the "crosses" was shown only by the former class, while the latter indicated the weather clearing up. The former class, however, did not show its full effect unless the upper drift seemed to be of warm origin. The former was sometimes referred to successfully as the reliable foreteller of a cyclone being formed at some distance.

(6) As a result of statistical study it was shown that moving anticyclones in the neighborhood of Japan have general tendencies to move the more rapidly, the more prominently appear the "crosses" on the rear of them.

(7) By means of the isobaric charts for successive heights the thickness of anticyclones has been estimated, and it was found that very thick [vertical depth] HIGHS persisted fairly long, while very thin ones faded away in a short time.

(8) The observations of pilot balloons generally showed fair accordance with the trend of upper isobars except when the station (Kobe) happened to be near the point of sharp recurvature of isobars.

(9) The existence of the surface of discontinuity has been indicated and its height at the point of observation fixed with fair accuracy by means of pilot-balloon observations. Sharp bending of the trajectory attended by sudden change of wind speed has been taken as a sign of transition between two distinct drifts, one over another. Shortly after such a surface of discontinuity a change from anticyclonic to cyclonic type of weather was usually perceived, especially when the abrupt change of wind direction from some easterly point to southwesterly point at some height near 3,000 meters was observed. Steady northwesterly, northeasterly, or southwesterly winds, retaining those directions up to several thousand meters without any remarkable change, seemed to suggest the persistence of anticyclonic weather.

(10) In the colder season, so long as the general trend of the upper isobars in the East China Sea and the Yellow Sea was from some northwesterly to southeasterly point, the general weather conditions in Japan were good and steady. As the weather declined they gradually changed to horizontality—that is, west to east trend. Finally the trend became directed from some southwesterly point to northeasterly as a continental cyclone approached the east coast of China. The whole appearance of the chart of upper isobars gives an impression of a wavy system moving slowly from west to east. In many cases watching such movement was very helpful to the author in seizing upon the first sign of cyclonic approach.

(11) Nearly opposite directions of upper and lower isobars during the winter monsoon rains in the East China Sea should be taken into account in the explanation of that phenomenon which was formerly explained simply by the orographic effect. The fairly strong and steady southwesterly wind prevailing thereabout (and also along the Pacific coast of Japan proper) in summer, with the upper and lower isobars in the same direction, does not generally bring about continued rain like that of the winter season.

(12) There have been many instances of heavy rain which can be suitably explained only by supposing the existence of instability that may have been arising from the invasion of a cold drift of air over a warm one, as shown by the trend of upper and lower isobars.

Thus I have summed up my experience briefly. Reflecting upon the method used, the weakest point lies in the uncertainty of the lapse rate. Notwithstanding, we have proceeded with our eyes closed to it, for a while, in eagerness to raise the percentage of successful forecasts on any reasonable ground, leaving further refinements and improvements of the method to later investigations.

DISCUSSION.

American meteorologists will appreciate this generous act of Doctor Sekiguchi in pausing from his busy European visit to commit to writing these precepts for forecasting from free-air isobaric charts, as determined by Japanese experience. The intrinsic merit of such charts which represent (when accurately drawn) *real* conditions, in contrast with *hypothetical* conditions shown upon the sea-level charts, has long been recognized. But the difficulty of correctly estimating the temperature conditions in the free air has led to the general acceptance of sea-level as a reduction plane, it being much easier for us to have faith in the temperature of an air column which does not exist than in one which does, when actual measurements are not possible. We have chosen, rather, to "bear those ills we have, than fly to others, that we know not of."

But the accessibility of aerological data in constantly-increasing quantity has given rise to an unmistakable tendency for forecasters to give attention to free-air conditions, with a view to adapting the information thus gained to the improvement of the current forecast. In a country so large as the United States, where so many influences are operative, it is far from easy to read at once the significance of these free-air phenomena. This practical message of Doctor Sekiguchi comes, therefore, at once as a challenge and as an encouragement to those who look to the free-air for forecasting aids.

The process of collecting aerological information at numerous well-distributed stations is an expensive one, and the desirability of basing the free-air map upon surface conditions is apparent. The method used in Japan is clever; but, as Doctor Sekiguchi shows, it is chiefly applicable to the stations subject to marine influences. The short distance between the stations on the east and west coasts of Japan enables one to draw the isobars without giving much heed to the interior stations, which show the effects of an incorrect temperature argument. But we, in the United States, can not escape the difficulties so easily, because of the relative paucity of, and great longitudinal distance between, coastal stations. The problem is to find a way that will satisfy our needs.

Doctor Sekiguchi's paper, while perhaps not offering a group of precepts that we can take over bodily and apply to our work, does remove, in a large measure, whatever anxiety we may have had as to the usefulness of such charts and allows us to concentrate upon producing something that will help us as much as the Japanese maps have helped the forecasters at Osaka, Kobe, and Tokyo.—*C. Le Roy Meisinger.*